

APPENDIX D

# AMD Storage Conceptual Designs

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# AMD Storage Conceptual Designs

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This memorandum presents conceptual designs for acid mine drainage (AMD) storage options within the Bunker Hill Mine.

## 1.0 Background

AMD storage options were previously reviewed in the report, *Bunker Hill Mine Water Presumptive Remedy* (CH2M HILL, 1999). The review and subsequent recommendations were based on the assumption that all AMD flow throughout the year would be delivered to the Central Treatment Plant (CTP). Further, only during infrequent plant shutdowns would in-mine storage be used. The report recommended keeping the mine pool pumped down to below 12 Level and then temporarily flooding 12 Level if in-mine storage was required for a CTP shutdown.

Since that report was issued, total maximum daily loads (TMDLs) have been developed by the U.S. Environmental Protection Agency (EPA) for the South Fork Coeur d'Alene (SFCdA) River. The TMDLs specify loads for cadmium, lead, and zinc that can be placed in the river, depending on SFCdA River flows. One method of meeting the TMDL discharge requirements is to store AMD in the mine for treatment later when river flows are higher and allow a higher discharge rate. This could be useful during periods of high AMD flow and low SFCdA River flow. Also, since that report was issued, use of the existing volume above the current mine pool has been evaluated. This volume is currently used by the mine for working or contingency storage. The benefit of this option is that the mine water does not need to be lowered, and hence the piping and pumping distances are less, which will reduce the long-term power consumption and maintenance requirements.

### 1.1 Purpose and Objectives

This technical memorandum presents conceptual layout and cost information for installing diversion and pumping facilities at the Bunker Hill Mine. Options for using the storage above the existing mine pool (11 Level) and new storage created by lowering the water level to below 12 Level are evaluated.

This document uses the term "storage" to indicate raw AMD stored in the Bunker Hill Mine. A number of other storage options exist, including treated water storage ponds and alternative water uses that could reduce or eliminate the need for storage. However, these options are beyond the scope of this memorandum.



## 1.2 Limitations

Detailed design has not been conducted on any of the approaches summarized in this technical memorandum. The concepts and resulting implementation costs have been developed for comparison with the costs and benefits of other components for long-term water management at the Bunker Hill Mine. The conceptual designs are based on existing data only.

Order of magnitude cost estimates have been prepared based on conceptual designs. The cost estimates are in January 2000 dollars and do not include escalation. They were prepared using information available at that time, and therefore may be subject to adjustments in the scope and details of each design. The cost estimates have been prepared for guidance in project evaluation and should be carefully reviewed prior to making specific financial decisions or establishing final project budgets. The actual costs to implement any of the mitigation approaches are expected to vary from the costs shown herein based on actual labor and material costs, competitive market conditions, final project scope, and other variable factors.

## 2.0 Diversion to Storage Using Gravity Flow

### 2.1 Location

Two diversions are necessary to allow flexibility in the rate of AMD diverted to storage. One diversion point would be located near No. 2 Shaft, and a second diversion would be located on the Barney Drift. Each diversion would consist of two fabricated slide gates and a new diversion channel. The diversion channel would lead from the AMD channel to a new inlet funnel and diversion pipe mounted in No. 2 Shaft at the 9 Level and at a suitable location in the Barney Drift. The slide gate on the main channel would be partially lowered (closed) and the slide gate on the diversion channel raised (opened) to divert the AMD to storage. See Figure 1 for a diversion layout sketch.

### 2.2 Gate Type and Material Selection

The gate frame bottom would be mounted flush with the channel floor. Gates would have a self-contained frame and motorized operator. The gate frame would be 316 stainless steel (SST) and the gate disk would be fiberglass. The gate disk would have a bottom rubber seal and polyethylene guides in the frame. The gate seal would not be drop-tight but would close off most of the AMD to the diversion when diversion is not required. Materials would be selected for corrosion resistance. Ongoing maintenance will be needed to prevent the gate seals from fouling by mine muck and yellow boy. For this reason, other diversion configurations may be considered during design.

### 2.3 Diversion Pipe

The diversion pipe would be high-density polyethylene (HDPE), 12 inches in diameter. Because the pipe would flow by gravity, a standard dimension ratio of 17 is assumed. The pipe is large to address the uncertainty in peak diversion flow requirements. A riser-type clamp system would be required to hold the diversion pipe in place. Spacing for the clamps would need to be sized during final design. For the conceptual design, 10-foot on-center is

assumed. The top section (approximately 10 feet long) of the diversion pipe might have to be 14 inches in diameter to minimize entrance headloss and assure smooth entry of the diverted flow. A fabricated metal (SST) box with funnel bottom would be included to lead the diverted flow from the channel to the diversion pipe.

## 2.4 Flow Measurement with Cutthroat Flumes

Cutthroat flumes would be used to measure the diverted flow and the AMD flow that continues toward the Kellogg Tunnel portal. The flumes would be constructed of fiberglass for corrosion resistance. An ultrasonic level element would be installed above each of the two flumes. These elements, with associated hardware and software, would be used to measure the water level reading for each flume. Isolation (and throttling) slide gates would be located upstream of the flumes so as not to submerge the flume throat and destroy flow measurement accuracy. During final design, the size and type of flume and flow measurement equipment should be revisited to assure that the best combination of flow accuracy and maintainability is provided.

## 2.5 Conduits and Conductors

To control the slide gates and transmit channel level measurements to the CTP, conductors would be extended in conduits along the 9 Level tunnel to the Kellogg Tunnel portal. From the portal, the conduits could be buried and extended to the CTP. The estimated distance for these conductors is 10,000 feet.

Power for the slide gate operators (480 volts) is assumed to be available near the No. 2 Shaft for extension to the diversion gates.

# 3.0 Storage Levels

## 3.1 12 Level Storage

12 Level has approximately 80 million gallons (MG) of storage (12 Level track to 11 Level track). The typical water level would be at 20 to 30 feet below 12 Level. The mine water would need to be lowered about 200 feet for this option.

## 3.2 11 Level Storage

This option would use the existing storage used by the mine, which consists of about 20 MG from 30 feet below 11 Level up to the 10 Level, and an additional estimated 190 MG from the 11 Level track to the 10 Level track.

# 4.0 Pump Layout Options

Conceptual pump layouts are described below for both 11 Level and 12 Level options.

## 4.1 Conceptual Layouts

A variety of pumping options could be used to satisfy the AMD storage pumping needs. Figure 2 shows the conceptual pump layout for the 12 Level option, which uses a vertical turbine pump for the first pump and either a horizontal centrifugal or possibly a vertical can

pump as the booster pump. Figure 3 shows the option for 11 Level storage. In this case, only the vertical turbine pumps are needed because they could pump directly to 9 Level without booster pumps. Both options could allow the water level to fluctuate an entire level, but typical water levels in the absence of diversion would fluctuate about 10 to 30 feet. The submersible vertical turbine pump could operate at this depth of submergence (about 200 feet) without damage.

Many flow rate options exist that could be met using multiple single or variable speed pumps. Use of variable speed pumps is discussed in Section 5 of this technical memorandum. The least cost option would be constant speed pumps. Constant speed pumps are used in the existing AMD pumping system. The following conceptual layouts use two 700 gallons per minute (gpm) constant speed pumps, which could provide nearly twice the capacity of the existing system, which is about 700 gpm.

## **4.2 12 Level Option**

This option uses two 700 gpm constant speed vertical turbine pumps (Pump A) mounted approximately 20 feet below the bottom of 12 Level as shown in Figure 2. These would discharge flow through a 12-inch SST pipe to the suction of two centrifugal pumps (Pump B) located in the shaft near 11 Level, or on the 11 Level. Each Pump B would have an air release valve on its suction side, and check and isolation valves on its discharge. The discharge from Pump B would be carried up No. 2 Shaft in a SST pipe to the discharge on 9 Level. Isolation and check valves would be provided on the discharge sides of Pumps A and B.

SST pipe is recommended for corrosion resistance and the higher pressure rating needs of this installation. Costs would be comparable to costs for HDPE pipe with the same pressure rating.

## **4.3 11 Level Option**

The 11 Level option uses two pumps to provide about 700 gpm each, which could pump directly to 9 Level without booster pumps, as shown in Figure 3. These would be constant speed vertical turbine pumps located about 30 feet below 11 Level. More in-shaft storage volume could be obtained by placing them lower in the shaft and drawing down the water.

## **4.4 Water Depth Monitoring**

The water level (top of the mine pool) could be monitored using a bubbler tube or other system. The bubbler tube discharge point would be mounted at a known elevation in the No. 2 Shaft. The bubbler system might need two pressure transducers: one to accurately read pressure when the water level fluctuates slightly, and the other for greater fluctuations. Submersible pressure transducers could also be used for level measurement, but the bubbler system may be better-suited for the mine water.

## 5.0 Flow Control

### 5.1 Throttling

Constant speed pump output could be reduced with a throttling valve on the pump discharge side. The throttling obviously would expend additional energy for the volume pumped, as well as creating additional costs associated with the throttling valve installation, repair and, ultimately, replacement. The throttling valve could be positioned by an electric operator. A flow meter upstream of the valve would monitor flow rate.

### 5.2 Variable Speed Drive

For the AMD pumping options, some reduction in flow could be achieved with a variable frequency drive (VFD). It is estimated that the flow rate could be reduced about 30 percent with a VFD. If a VFD were used, it would most likely be located at the 9 Level. Care would be needed to ensure the VFD was installed in an environment that could provide long service life. The inside of a mine is not an ideal location for installation of a VFD, because of moisture and corrosion concerns. With either a VFD or a throttling valve, the pump output could be controlled by an operator at the CTP.

### 5.3 Multiple Pumps

One method of providing pumping rate flexibility would be to use multiple constant speed pumps of different sizes. For example, a 700 gpm pump and a 1,200 gpm pump could provide three levels of pumping (700, 1,200, and 1,900 gpm).

Judging by the size of the No. 2 Shaft, it might not be practical to install multiple pumps. This option should be revisited during final design.

## References

CH2M HILL, 1999. *Bunker Hill Mine Water Presumptive Remedy*. Bunker Hill Mine Water Management, July. CH2M HILL, Spokane, Washington.

# Storage Diversion Layout

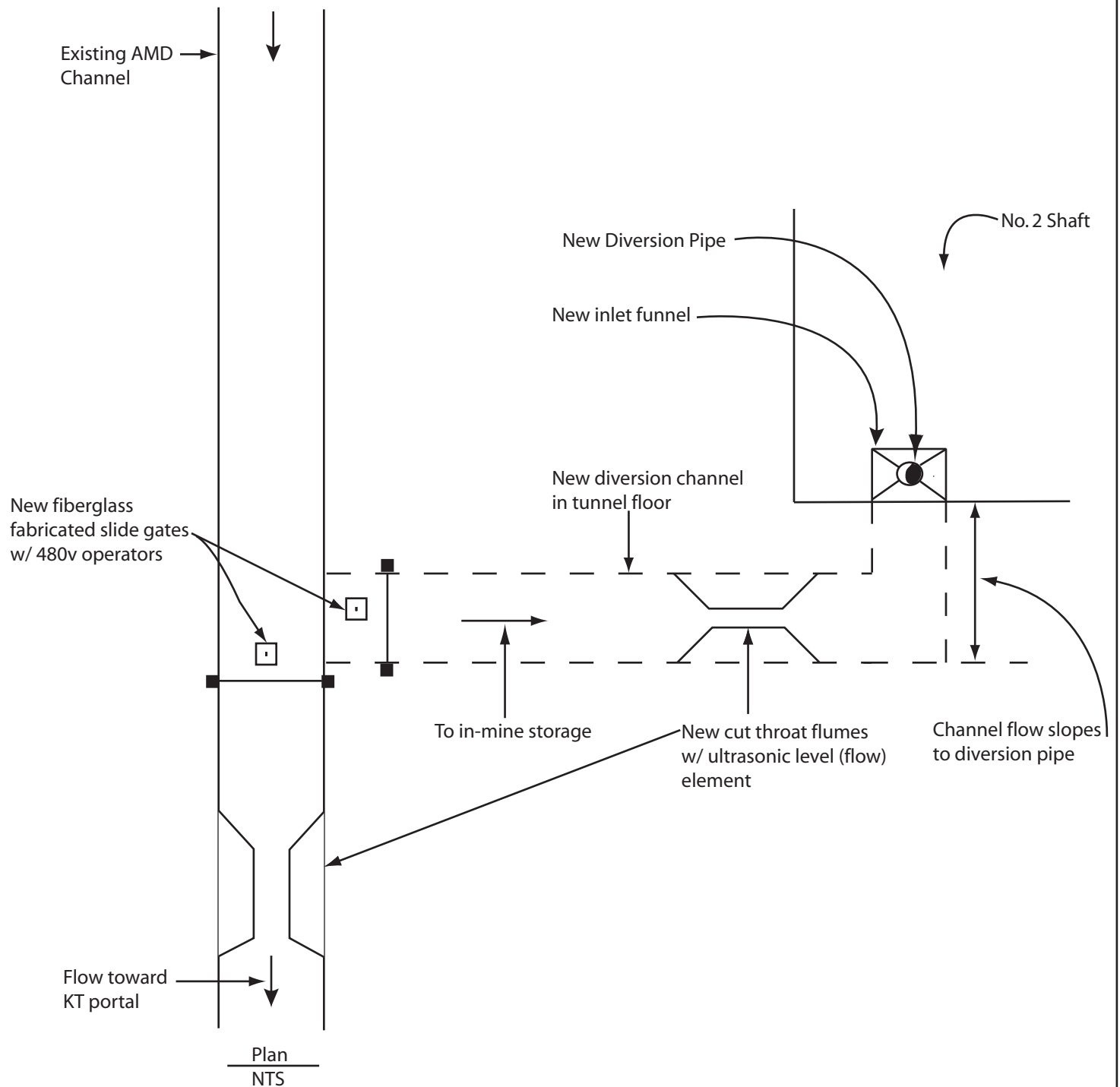


Figure 1  
Storage Diversion Layout

# 12 Level Pumping Layout

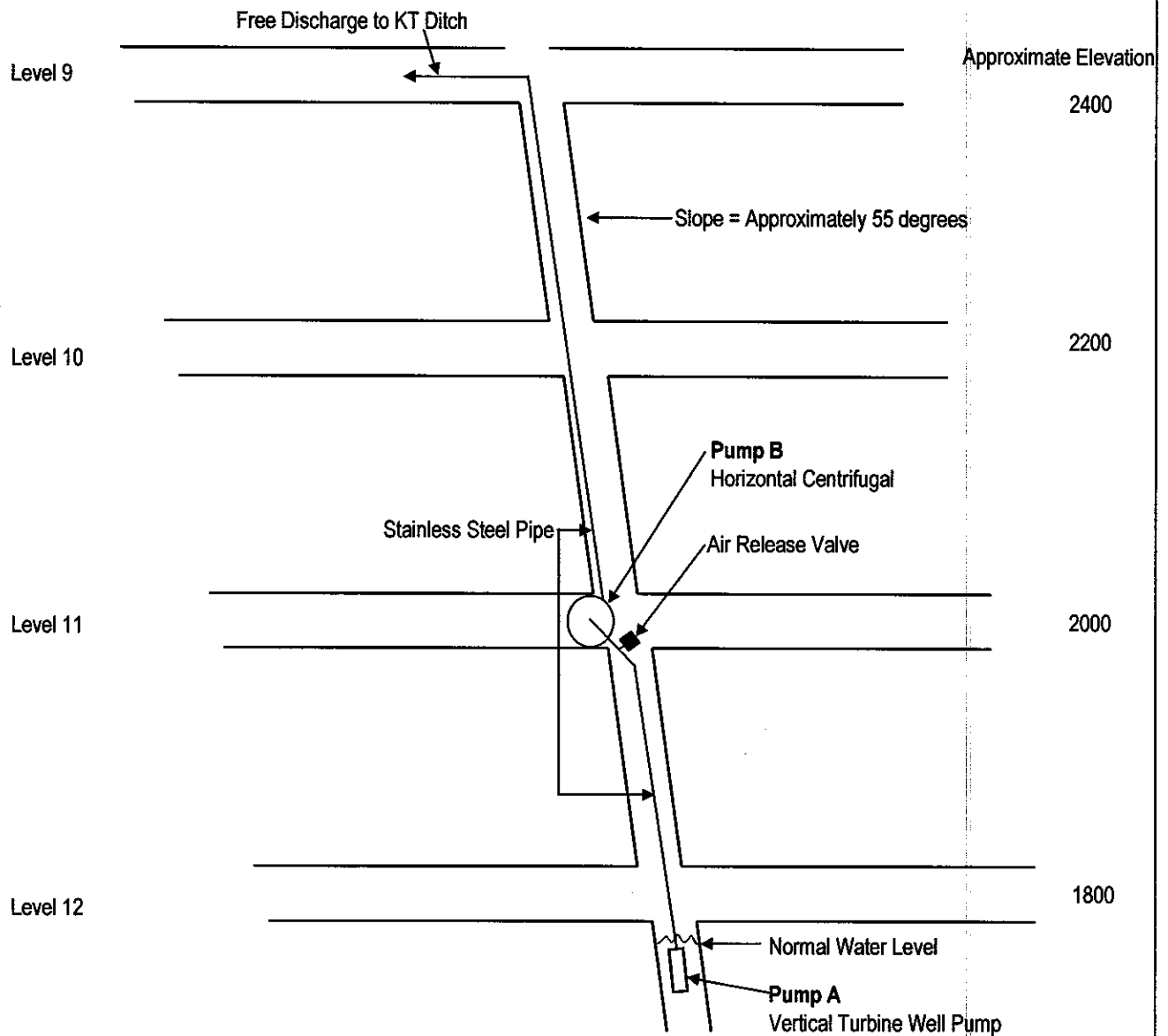


Figure 2  
Conceptual Pumping Layout  
for 12 Level Option



# 11 Level Pumping Layout

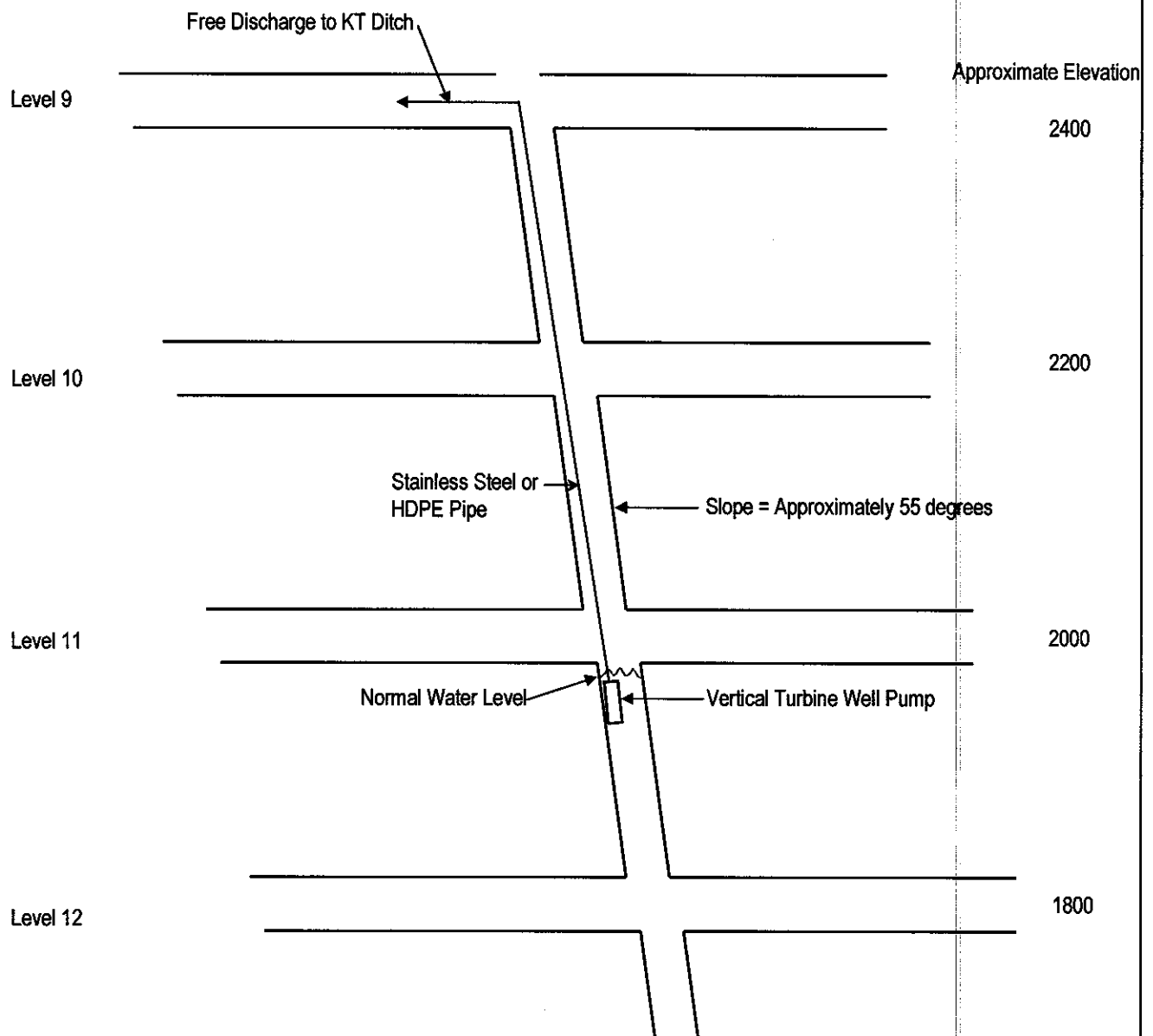


Figure 3  
Conceptual Pumping Layout  
for 11 Level Option